NanoMaterials Group

Summer student projects 2019

The NanoMaterials Group (NMG), headed by Prof. Esko I. Kauppinen, is among the top aerosol technology laboratories in the world and offers a unique environment for strong interdisciplinary research and a proven track record of productive cooperation.

We offer summer projects related to the carbon nanotube film from floating catalyst chemical vapor deposition (FCCVD) method.

The projects include the following topics.

1. Direct Synthesis of Colorful Single-Walled Carbon Nanotube Thin Films by FCCVD method
2. High-yield preparation of transparent and conductive films with larger-diameter CNTs


Fig 1. (a) Optical image of colorful SWCNT thin films on filters directly fabricated by FCCVD method and Chirality distribution of individual SWCNTs in green film (b) corresponding absorption spectra of colorful SWCNT thin films.

Single-walled carbon nanotubes (SWCNTs) have attracted massive attention owing to their exceptional structural and electronic properties. Because the electronic and optical properties of
SWCNTs critically depend on their chirality, it is important to achieve SWCNTs with narrow chirality distributions. In floating catalyst chemical vapor deposition (FC-CVD), tuning chirality distribution and obtaining narrow chirality distribution of single-walled carbon nanotubes (SWCNTs) is challenging (1). Herein, by introducing various amount of CO2 in FC-CVD using CO as a carbon source, we have succeeded in directly synthesizing SWCNT films with tunable chirality distribution as well as tunable colors first time (2), as shown in Fig 1. In particular, with 0.25 and 0.37 volume percent of CO2, the SWCNT films display green and brown colors, respectively. We ascribed various colors to suitable diameter and narrow chirality distribution of SWCNTs. In this summer project, we are going to prepare SWCNTs films with more colors by more precise control on chirality and diameter distribution of SWCNTs and bundle morphology in FCCVD. As a summer student, you will learn how to run the FCCVD reactor of CNT synthesis and control SWCNT synthesis, get training in TEM, SEM, electron diffraction in TEM, absorption spectra from UV–vis–NIR spectroscopy, 4-point probe system of resistance measurement, and also learn corresponding knowledge in the fields of material physics and condensed matter physics.

2. High-yield preparation of transparent and conductive films with larger-diameter CNTs (experimental, characterization)

Fig 2. Controllable synthesis of carbon tubes in high-yield FCCVD reactor. Diameter distribution and bundle morphology of CNTs were modified by tuning the sulfur amount to improve CNTs films conductivity.
Recently, the demand for transparent conducting films has surged due to the expansion of the commercial market for optoelectronic devices such as liquid-crystal displays, touch panels, photovoltaics, and organic light-emitting diodes. Because of their high stretchability, mechanical flexibility and excellent optoelectronic properties, the thin carbon nanotube (CNT) films as a novel transparent conducting material, has attracted tremendous attention, especially in the flexible electronics. Floating catalyst chemical vapor deposition (FCCVD), an important method used for CNT growth in both fundamental science and industrialized production, can directly fabricate CNT films (3). The performance and yield of CNT film are related to CNT synthesis which depends on catalyst composition, catalyst size, carbon source, temperature, and gas-phase chemistry -- the five principal parameters for FCCVD (4).

In this summer project, we are going to study and optimize synthesis conductions to improve the conductivity and yield of CNT film by control catalyst composition and size in FCCVD. Specially, we will build and run a new FCCVD reactor based on CH4/Ferrocene/Sulfur system with 100 times higher yield than that of the exiting reactor. We will modify diameter distribution and bundle morphology of CNTs by tuning the sulfur amount to improve CNTs films conductivity, as shown in Fig 2. As a summer student, you will learn how to build and run a FCCVD reactor of CNT synthesis and control SWCNT synthesis, get the training in TEM, SEM, absorption spectra from UV–vis–NIR spectroscopy, 4-point probe system of resistance measurement, and also learn corresponding knowledge in the fields of Condensed Matter Physics, Physical Chemistry and Aerosol science.

References


For more information on our research in general, check out the group website or contact nan.wei@aalto.fi, qiang.zhang@aalto.fi, esko.kauppinen@aalto.fi.